REMARKS/ARGUMENTS

The examiner is thanked for thoroughly reviewing the subject patent application. Applicants wish to point out the major features of their invention, which is a method for forming a hard bias layer within an abutted junction configuration for a spin-valve type GMR read head. The presentation below is slightly different from the explanatory material presented in the previous Office Action response, to further stress the attributes of the present invention and to distinguish it more precisely from the prior art now cited by Examiner.

It is the central object of the present claimed invention to provide a method of forming a thin hard bias layer against the substantially vertical etched side surface of a spin-valve GMR sensor element in order to form an abutted junction configuration. Moreover, the formation of the bias layer must be such as to enhance its magnetic properties at the junction region, because it is found that as the width of the sensor element increasingly diminishes, it is the magnetic properties of the bias layer at the junction that dominate the performance of the sensor. Further, in order to be able to make the hard bias layer as thin as possible, it is also necessary to have very good lattice matching between the bias layer and the etched surface of the sensor against which it abuts. As is illustrated in Fig. 1 of the present application, the undersurface of the bias layer must form a contiguous junction with the etched surface of the GMR sensor element. This etched surface includes exposed side edges of all the horizontal layers

forming the GMR sensor element and, in addition, it includes small horizontal projections extending from a first seed layer beneath the GMR sensor element, that are shaded for emphasis and labeled 13 in Fig. 1. In order to accomplish the lattice matching against such a variety of materials and surface shapes, particularly the projections from the first seed layer, the present claimed invention teaches the formation of a second lattice matching seed layer, 14 in Fig. 1, that covers all portions of the surfaces described above. It is on this second seed layer that the hard bias layer is then formed.

The second seed layer meeting the objects of the invention is a layer of CrX formed over a layer of Ta, where X can be Ti, W, Mo, V or Mn. It is found by extensive experiment, described by reference to tables 1.1, 1.2, 2.1 and 2.2 within the specification, that the combination of a Ta layer beneath a layer of CrTi most advantageously screens out the effects of the horizontal projections of the GMR first seed layer 13. As noted in the Application, such a projection is an unavoidable product of the etching process used to form the surface for the abutted junction and it is the second seed layer of the present claimed invention that prevents that projection from adversely affecting the structure of the bias layer by creating a lattice mismatch. The hard bias layer, which is a layer of either CoCrPt, CoPt or CoCrTa, is, therefore, rendered structurally uniform by the presence of the seed layer. Applicants would again stress the fact that the significantly improved junction properties of the present claimed invention are substantiated by the empirical results presented in tables 1.1, 1.2, 2.1 and 2.2.

Having thus briefly explained the invention, Applicants would like to address the specific objections of the Patent Examiner.

Claim Rejections Under 35 USC 112

Applicants respectfully request the reconsideration of the rejection of claims 1-14, as currently amended, as being indefinite for failing to point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1 and 8 have both been amended so that it is clear that only one spin-valve GMR sensor element and one hard magnetic longitudinal bias layer are referred to in both the preamble and the body of the claims. Claims 2-7 and 9-14 now depend from claims that are not indefinite under 112 and their rejection should also be reconsidered.

Claim Rejections Under 35 USC 103

Applicants respectfully request the reconsideration of the rejection of claims 1-14 as currently amended, as being unpatentable over Shen et al. (US Patent No. 5,742,459).

The present claimed invention, as illustrated in Fig. 1 of the subject Application, teaches a method of forming a thin longitudinal bias layer against the sides of a GMR sensor that has been etched to allow the formation of abutted junctions. The bias layer formed by the claimed method is found to have excellent magnetic properties within the junction region, which is extremely advantageous for the operation of a narrow sensor.

The etching process to form abutted junctions produces sharp horizontal projections (13 in Fig. 1) at the extreme lateral edges of the first seed layer (12 in Fig. 1) on which the GMR sensor is formed. These projections would normally prohibit the uniform formation of a thin bias layer with good magnetic properties, because the

projections would prevent proper lattice matching between the first seed layer and the hard bias layer. The novelty of the present invention is that it provides a second, intermediate seed layer (14 in Fig. 1) that produces a crystalline match with the first seed layer having the projections. As is seen in Fig. 1, the hard bias layer (16 in Fig. 1) can then form a thin and smooth layer over the entire surface of the second seed layer. By forming the bias layer smoothly and in a lattice matched condition over the entire surface of the second seed layer, the bias layer then effectively exerts its advantageous effects on the entire GMR sensor.

Shen et al. do not disclose the same GMR sensor structure of the present claimed invention. Their hard bias layer (52 in Fig. 1 of Shen) only partially covers the lateral edge of their GMR sensor. In fact, their bias layer abuts a soft transverse bias layer (34 in Fig. 1 of Shen), and is substantially below the GMR element itself (25 in Fig. 1 of Shen).

Shen et al. teach the formation of an encapsulated GMR sensor, the purpose of the encapsulation being to prevent diffusion and electromigration (column 3, lines 8-12) from structures such as bias layers and conducting lead layers into the sensor itself. Their encapsulation is provided by the formation of a junction spacer layer (32 in Fig. 1 of Shen) and an optional overcoat layer (45 in Fig. 1 of Shen and described in column 4 line 11 of Shen) that is formed on the abutted sides of their GMR sensor 25 and its transverse bias layer 34. According to Shen et al., the purpose of the junction spacer layer is to: "minimize diffusion and electromigration" (column 3, line 12) and to "physically separate the central region 18 from the side regions 20,22" (column 3, lines 64-66). Moreover, the shape of the lateral edges of Shen's structure is smooth and gradual, it does not show the sharp, vertical edge of the present claimed structure. Shen's structure

does not present the sharp horizontal projections of the present claimed structure that necessitate the formation of the second seed layer of the present claimed invention.

There is no indication in Shen of a purpose to form a thinner, magnetically improved hard bias layer abutting the etched sides of a narrow GMR sensor element. Neither is there any indication of an intent to form an intermediate seed layer to provide lattice matching between a first seed layer and a hard bias layer. Shen clearly states that the purpose of the capping layer 26, the spacing layer 27 and the junction spacer layers 30, 32, is "to protect the central region 18 by preventing it from directly contacting any material other than its encapsulating layers, in order to minimize diffusion and electromigration" (column 3, lines 8-11). Shen is teaching a method of protecting a GMR sensor element from damaging effects of structures formed abutting it, such as bias layers and conducting layers.

Applicants must respectfully disagree with Examiner's characterization of Shen's invention. Examiner characterizes Shen's layer 45 as a lattice matching second seed layer that is presumably the same as layer 14 in Fig. 1 of the present claimed invention. Yet Shen describes identical, symmetrically placed layers 44 and 45 as "overcoat layers" (column 4, lines 10-20) and notes that "In alternative designs the overcoat layers 44, 45 may be omitted entirely" (column 4, line 18). It is difficult to understand how a seed layer that is necessary to produce a lattice matched bias layer could be omitted. Applicants respectfully suggest that layers 44 and 45 are protective layers that serves to improve the encapsulation of Shen's GMR sensor element. This seems a reasonable interpretation in light of Shen's own words. Applicants would also respectfully point out that Shen provides no experimental results to establish a relationship between the

magnetic performance of his hard bias layer and the materials forming his spacer layers 32 and 30 and his overcoat layers 44 and 45. The subject application, on the other hand, in tables 1.1, 1.2, 2.1 and 2.2, demonstrate an important relationship between the structure of the second seed layer and the performance of the bias layer. Applicants would respectfully suggest that these differences between the teachings of Shen et al and the present claimed invention are a strong indication that the present claimed invention is directed at improving the performance of a hard bias layer, whereas Shen teaches a method of protecting a GMR sensor by a process of encapsulation.

Examiner's suggestion that the present claimed invention is obvious in light of Shen and therefore is unpatentable over Shen seems, to Applicants, to be at odds with the nature of Shen's teaching. A reading of Shen by one skilled in the art would suggest a method of protecting a GMR sensor from structures formed abutting its sides. In particular, it suggests a method of protecting a GMR sensor from directly contacting any material but the material forming its encapsulation layers and, therefore, of protecting the sensor from diffusion or electromigration of the material species forming the biasing layers or the conduction layers. One skilled in the art would not be drawn to Shen in an effort to discover a way of improving the magnetic properties of an abutting hard bias layer or of forming a thinner hard bias layer over the sides of a GMR sensor and its seed layer's horizontal projections.

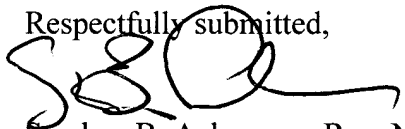
In an effort to more clearly describe the present claimed invention, claims 1 and 8 have been amended to recite the fact that the second seed layer covers the horizontal projections of the first seed layer and, by so doing, provides a lattice matching condition between the hard bias layer and the sides of the GMR sensor element. A comparison of

independent claim 1 of the present claimed invention and independent claim 1 of Shen et al. provide a clear and patentable distinction between the inventions.

Conclusion

The Examiner is thanked for thoroughly reviewing the application. All claims discussed above are now believed to be allowable. If the Examiner has any questions regarding the above application, please call the undersigned attorney at 845-452-5863

Respectfully submitted,



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